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ORIGINAL ARTICLES.

I.—The Ambrym Eruptions of 1913–14.[1]

By Professor J. W. Gregory, D.Sc., F.R.S.

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1. The Constituents of the New Hebrides.

THE rocks of the New Hebrides belong to at least four groups—two series of limestones and two series of volcanic rocks. The islands are sometimes referred to as if composed only of recent volcanic and coral formations. The existence of a series of old rocks has been believed from the records of gneiss on Espiritu Santo by Levat, and of ores of iron, copper, and nickel. The asserted presence of these materials suggested that the older rocks of New Caledonia form the foundation of the New Hebrides. The existence of the ores and gneiss is, however, discredited by Sir Douglas Mawson (1905, pp. 422, 434–5); he remarked that he had examined "small samples of copper, manganese, and other ores *supposed* to have been collected in the group" (Mawson, 1905, p. 435). He did not confirm this supposition, though admitting that traces of these metals might occur.

Lieut. Frederick (1893) obviously identified some of the New Hebrides rocks as "claystones", which may indicate that he recognized some older sediments. If this statement had been confirmed it would have been his most important contribution to the geology of the archipelago; but it was apparently distrusted, and was excluded from his published paper; and his identification is only known from a remark by Sir Archibald Geikie in the discussion.

[1] [The description of the Volcanic Eruption of 1913 on Ambrym Island, New Hebrides, by the Rev. M. Frater, appeared in the Geological Magazine for November, 1917, pp. 496–503, and was communicated by Professor J. W. Gregory to the Editor.]

Although the existence of the suspected early rocks is unconfirmed, Sir D. Mawson collected at Espiritu Santo a series of limestones which Mr. Chapman (1905, p. 273) identified by their Foraminifera (*Lepidocyclina*) as Aquitanian and Burdigalian. They are therefore Lower Miocene, and would be also Upper Oligocene according to the classification which refers the Aquitanian to the Oligocene.

These *Lepidocyclina* limestones are shown by Mawson to rest on an older volcanic series, which he attributes to the Oligocene or the base of the Miocene. The limestones are burst through by a later volcanic series, the earlier tuffs of which Mawson regards as possibly Pliocene. These tuffs form the beginning of the volcanic period that includes the modern eruptions.

The Miocene rocks occur in south-western Espiritu Santo, and their arrangement shows that they are part of a great upfold which formed the New Hebrides ridge.

The later limestones are recent coral reefs. Some of them have been raised high above sea-level. On Efate (Sandwich Island) limestones, which are regarded as raised coral reefs, occur 1,500 feet above sea-level (Frederick, 1913, p. 227).

The bulk of the archipelago consists of volcanic material belonging to the later eruptions. The archipelago is part of the great volcanic line which passes along the Pacific border of Australasia from New Guinea through the Solomon Islands to New Zealand. The New Hebrides volcanoes have been in frequent eruption. Tanna, as Mr. Frater remarks, is of the Strombolian type owing to its chronic activity since it was seen in 1774 by Captain Cook, who was the first European to visit the Archipelago. Ambrym was also then in eruption. Lopevi, to the south of Ambrym (4,755 feet high), is a smaller island with a regular volcanic cone. It was in eruption in 1864 (Purey-Cust, 1896, pp. 3–4). It is said to be the highest peak in the archipelago, though according to the *Sailing Directory, Pacific Islands*, vol. ii, 4th ed., 1908, p. 385, Espiritu Santo rises to between 5,000 and 6,000 feet.

2. The Volcanic History of Ambrym to 1894.

The eruptions on Ambrym occur at irregular intervals and include explosions of paroxysmal violence. The records collected by Admiral Purey-Cust (1896, pp. 5–6) indicate a disastrous eruption, which, judging from the probable age of the old man who remembered it, happened about 1820. Like the chief later eruptions, it was at the western end of the island; it poured lava into the sea at Craig Point. Moderate activity is recorded by the officers of a mission schooner, the *Southern Cross*, in 1870, and it is also reported as having been in eruption in 1883 or 1884 (Purey-Cust, 1896, p. 3). Lieut. Moore of the *Dart* stated that in 1883 large quantities of volcanic dust fell from Ambrym to the north and north-west of the island, but that no lava had been discharged for some years (Purey-Cust, 1896, p. 5). Mt. Marum, one of the two large craters in the middle of the island, was last active in 1888. A few months after it became dormant eruptions built up the crater known as "Volcano", of which the wall was breached by a lava stream, that

reached the sea at the south-eastern corner of the island. The old crater of Mt. Benbow has apparently not been active in historic times until 1913; it was visited by Lieut. Beresford from H.M.S. *Dart* in 1883, when the small crater on the eastern side of Mt. Marum was mildly active (Beresford, 1884, p. 131).

3. The 1894 Eruption.

The first great eruption of which there is adequate knowledge occurred in October and November, 1894. Fortunately Commander, now Admiral, Purey-Cust had just completed a survey of the island in H.M.S. *Dart*, and he was able to observe the eruption from all sides of the island and to visit the most interesting localities. He published a most valuable report on the eruption, issued by the Hydrographic Department of the Admiralty, with an appendix upon the rocks by Professor Judd. Most of Admiral Purey-Cust's report was also published in the *Geographical Journal* (vol. viii, pp. 585–602).

For comparison with the recent eruption the chief features of that of 1894 may be summarized from Admiral Purey-Cust's report. That eruption began on the evening of October 15, though the glare then was attributed to a bush fire. Early on the 16th it was obvious that one of the volcanoes was in active eruption, for at daybreak a high cloud was suddenly projected from the centre of the island. A lava stream, marked by a line of burning bush, was flowing down the northern slopes. It reached the coast at 7.45 a.m., just east of Krong Point. Its entrance to the sea was watched from the *Dart* at the distance of 300 yards. The lava stream was from 20 to 30 yards wide, and a pillar of steam rose to the height of 4,600 feet. In the afternoon flames appeared to the south of the Mission Station of Lon-wol-wol at Dip Point, and most of the natives were transferred from the settlements there to the north-western part of the island. Next day, the 17th, the south-eastern crater, Volcano, was quiescent, and the natives at Dip Point reported "Fire he finish"; it continued, however, further east, for at 4 p.m. a cloud pillar was shot upward from Mt. Benbow to the height of 15,000 feet. On the 20th the natives were taken back to the settlement at Dip Point, as the danger there was over. Commander Purey-Cust landed with a party and walked from Dip Point along the track southward across the island; progress on the path was barred by two narrow lava streams flowing westward from a large sheet of lava to the west of the village of Fo-luk. The smaller stream was 10 feet high and was flowing at the rate of 4 or 5 feet per hour. The larger stream was 300 or 400 yards wide. On October 23 Admiral Purey-Cust visited the centre of the island and reached the northern edge of the Benbow crater. It had a flat floor, about a mile in diameter, surrounded by precipitous sides from 800 to 1,700 feet high. On the floor of the crater was a group of vents from which steam was rising to the height of 2,000 to 3,000 feet above the crater. On November 7 another explosion from Benbow hurled a column of dust-charged steam in ten minutes to the height of 26,000 feet. On November 21 the crater of Benbow was revisited and it was found that a fissure vent had been opened on its floor, no doubt by the explosion of November 7. Lieut. Dawson

also on the 21st visited Mt. Marum. He described it as a perfect crater 1 mile east and west by three-quarters of a mile north and south, with very steep walls and a pool of water in the centre. It was therefore not active, but steam was rising from the small crater on the eastern side. Later eruptions of this series occurred at "Volcano", which was seen in eruption at the end of December, 1894, by the French man-of-war *Scorff*, and another eruption, apparently at the western end of the island, happened on February 10, 1895 (Purey-Cust, 1896, pp. 17, 18). The 1894 eruptions appear to have occasioned an uprise of 1 or 2 feet of the ground around Dip Point (Purey-Cust, 1896, pp. 21–2).

Admiral Purey-Cust concludes that this series of eruptions were confined to an approximately east and west line passing through Mt. Benbow, Fo-luk, and the western end of the island. At the north-eastern part of Ambrym even the earthquakes were slight, while neither the flow nor temperature of the hot springs on the northern and southern coasts was altered. Moreover, not only was Mt. Benbow active, while its neighbour, Mt. Marum, remained quiescent, but the two vents in the crater of Benbow, although only a few yards apart, seemed to lead from entirely different sources. He attributed the western eruptions to lava, finding no outlet in the centre of the island, having burst from the fissure where it traversed the lower ground at the western end.

4. The Features of the 1913 Eruption.

(a) *The Explosion Trough.*

The 1894 eruption was followed by nineteen years of comparative quiescence, though the vents on Mt. Benbow generally discharged clouds of steam. In December, 1913, a paroxysmal eruption followed on generally similar lines to the eruption of 1894, though with some more disastrous and remarkable effects. Mr. Frater's account shows that it began with a series of paroxysmal explosions followed by the emission of lava from a series of vents on an east and west line. The most dramatic episode of this eruption was the explosion which, like a mine, blew up the Mission Hospital of Lon-wol-wol. Admiral Purey-Cust (1896, p. 6) described the depression to the south of Dip Point, on the north-eastern side of Minnei Peak (1,245 feet), as a distinct old crater; he said it was half a mile in diameter, with an almost flat floor covered by scrub, bounded by perpendicular sides, and open, however, to the north. The new edition of the Admiralty Chart of Ambrym shows this crater better defined, for the breach on the north has been repaired. The main eruption of 1913 occurred to the north of this old crater on the plain formerly occupied by the Mission Station.

The chief line of modern volcanic activity on Ambrym through Volcano, Mts. Marum and Benbow, trends to the west-north-west, and if continued in that course beyond Fo-luk would pass under the site of the mission. The hospital was hurled into the air by an explosion just as that at Tarawera in New Zealand in 1886 blew up the Pink and White Terraces and scattered their fragments over the

surrounding area. This explosion on Ambrym formed a volcanic trough more than a mile long by about a quarter of a mile wide, with its floor in places 50 feet below sea-level; as it is breached to the north, the sea has poured in and the site of the hospital is now occupied by a somewhat fiord-like inlet, which is T-shaped, and has a threshold across its entrance. Subsequently a submarine eruption built up the base of Sealark Hill, which has been raised to the height of 330 feet, and has extended the island for about half a mile seaward.

The change produced in the outline of this part of the island by the eruption is shown on the map, Pl. XXXIII; the broken line represents the original course of the coast, taken from the Admiralty Chart of 1894, and the full line represents the coast after the eruption of 1913 from the survey of H.M.S. *Sealark* under Commander Hancock.

(b) *The Lava Pipes.*

A second remarkable feature of these Ambrym eruptions is that the lava-flows are extraordinarily narrow in proportion to their length. Thus in the eruption of 1894 the lava stream which entered the sea near Krong Point was over 6 miles long. Admiral Purey-Cust (1896, pp. 7, 13, 16) records its width at four places—at the shore, where it was 20–30 yards wide; further inland, 30 yards wide; at its sharp bend east of Fo-luk, 30 yards wide; and at its upper part along its east to west course, where it was in places only about 10 yards wide (Purey-Cust, 1896, No. 1, p. 16; but said to be 10 feet wide in 1896, No. 2, p. 600). The lava sheet west of Fo-luk fed two streams which flowed south-westward; both are represented on the map as very narrow. The southern stream discharged from a tongue some 300 or 400 yards wide (Purey-Cust, 1896, p. 9) projecting from the wide lava sheet. The lava stream of 1913 which reached the sea at Baulap, flowed from the eastern end of the Fo-luk fissure; it was 5 miles long and is represented on the Admiralty Chart as a long narrow sinuous line. The discharge from the vent to the south-east of Mt. Marum formed a wide lava sheet, 3 miles in length from east to west, and nearly 2½ miles wide from north to south; at its western end it gave rise to a lava stream which was discharged in January, 1914, and reached the sea at Port Vato; its length was 5 miles, and it also is represented on the new edition of the Admiralty Chart as a long narrow stream.

The Admiralty Chart no doubt indicates only the approximate course of the lava streams, and it is not intended to give precise evidence as to their width. Exact information as to the width of the flows would be of value. The available evidence indicates that they are remarkably narrow. Admiral Purey-Cust remarks (1896, p. 13) that the stream west of Fo-luk flowed down a deep gully; and the narrowness of the streams is doubtless due to their being confined between the banks of steep gullies. A stream 6 miles long and maintaining an average width of 30 yards must be fed by the flow of material down the centre while the outside has cooled to form a solid pipe.

Admiral Purey-Cust has described the upper part of the Krong Point lava stream as hollow, since he heard the flow of a swift stream of water along the centre (1896, p. 17). He also describes (ibid., p. 13) the lava stream in the gully west of Fo-luk as concave; the upper surface has apparently sagged owing to the central lava having flowed away and left the roof unsupported.

The characteristic form of the lava-flows on Ambrym is therefore that of lava pipes, in which the length may be 300 times the breadth, rather than lava streams of normal proportions.

(c) *The Fissure Eruptions.*

The tubular structure of these lava-flows is the more remarkable as most of them appear to have been the result of fissure eruptions. According to the Rev. M. Frater the lava from the western vents discharged from a series of fissures, through which the lava quietly welled forth without violent explosions. Thus he says that near Meltungan "streams of lava literally gushed out of the fissures without intermittent explosions of steam". According to the usual conception of fissure eruptions they normally give rise to sheets of lava; but the Ambrym lava must have been so liquid that it discharged through the lowest outlet from the fissure like water from a reservoir; this phenomenon is well illustrated by the narrow stream which overflowed from the great lava sheet south of Mt. Marum and reached the sea at Port Vato. If the fissure had been opened on the top of the level plateau it might have formed a widespread lava sheet; but as each fissure was discharged through a lateral notch into some narrow gully it gave rise to a narrow lava pipe.

That the western eruptions of Ambrym in 1894 also were from fissures is indicated by the descriptions of Admiral Purey-Cust. He states (1896, No. 2, p. 600) that at Single Palm Hill "There was no regular crater, and it was evident that the lava had burst up from the ground in all directions, and had been either violently impelled up the hillsides by hydrostatic pressure, or else the hillsides had been themselves split open".

Another striking feature of the eruption was the contrast between the quiet discharge from the fissure near Fo-luk and the explosion from the western end of the same fissure at Lon-wol-wol. According to Mr. Frater the lava that escaped quietly from the fissures was as saturated with steam as that which was thrown explosively from the central craters. This difference was probably due to the varying amount of water in the ground traversed by the lava. The fissure near Fo-luk ran along the central ridge of the island a little to the south of the crest, which there rises in places to 1,210 and 1,310 feet above sea-level. This ridge being well drained on both sides was relatively dry. The only steam available at the eruption there was brought up by the rising lava. But the fissure at Lon-wol-wol was close to the coast and only slightly above sea-level. The ground there was probably saturated with water, and the ascent of the lava along this fissure produced superheated steam, which suddenly found relief in the explosion that formed the volcanic trough.

5. The Rocks of the 1913 Eruption.

The volcanic rocks of the New Hebrides, according to the previous records, vary from andesites to basalts or dolerite. Professor Judd (in Purey-Cust, 1896, p. 23) described the specimens collected by Admiral Purey-Cust from Ambrym and some adjacent islands as being all very typical augite-andesites and as strikingly uniform in petrographic character. The dominant felspar he identified as microtine. Sir Jethro Teall (Frederick, 1893, App., pp. 229–30), who determined the collection brought by Lieut. Frederick from the New Hebrides, identified the specimens from the "hot ground" at 50 feet above sea-level on Tongoa (one of the Shepherd Islands to the south-east of Api), and from Tanna as augite andesites; the rock from the summit of Tongoa, 1,584 feet, he identified as basalt, and a specimen from the island of Makura as a dolerite. According to Sir Douglas Mawson (1905, pp. 459, etc.) the volcanic rocks of the New Hebrides are mainly andesites and basalts, including a hornblende-andesite at Efaté, and a basalt-porphyrite from Mau, an island north-east of Efaté. He estimates (Mawson, Proc. Linn. Soc. N.S.W., 1905, xxx, p. 463) the mineral composition of the latter as follows: its chemical composition is given as No. 2 on p. 538.

	1st Generation. Per cent.	2nd Generation. Per cent.	Total. Per cent.
Felspar-intermediate labradorite, $Ab_1 An_1$	33	—	33
Felspar-basic andesine, $Ab_3 An_2$ (*sic*)	—	26	26
Pyroxene	—	24	24
Olivine	1·8	8·2	10
Magnetite	Inseparable		7
			100
Apatite			minute.

Some lavas from the 1913 eruptions collected at Dip Point, Ambrym, by Professor W. M. Davis, and others obtained by Rev. P. Milne have been described by Professor Marshall (1915); he identified them all as basalts composed of bytownite-labradorite, diopside-augite, sometimes grains of olivine, and a brown glass densely filled with magnetite dust. Professor Lacroix has also described the lavas from the 1913 eruption and determined them as augitic labradorites too poor in olivine to be true basalts. According to his determination the normative mineral composition is felspar 64 per cent, diopside 22 per cent, olivine 5 per cent, magnetite and ilmenite 9 per cent.

Professor Lacroix includes an analysis by Boiteau, which is quoted as No. 1 in the table on p. 538. He calls the rock an andose allied to camptonose, of a kind frequent among basaltic lavas and as nearly allied to those of Kilauea. Some of the old lavas thrown out by the eruption he says are true basalts.

According to Professor Iddings (1913, vol. ii, p. 648) the volcanic rocks of the New Hebrides are chiefly basalts with phenocrysts of olivine.

Mr. Frater's collection includes representatives of the chief 1913 and 1914 lava-flows, and the rocks are all basalts, are mostly glassy,

and usually containing some olivine. The lavas represented are as follows.

The Baulap lava pipe, according to four specimens collected approximately equidistant along it, consists of olivine basalt and olivine-basalt glass.

The Craig lava-flow from the main fissures at Fo-luk discharged as a lava pipe down a gully; it then spread out as a wide sheet, from which a lava pipe descended almost to the sea near Craig Point. The specimens are very glassy basalts; in one of them I observed no olivine, which occurs, however, in a specimen from the lowest end of this flow near Craig Point.

The Lowea Valley lava-flow is a lava pipe that discharged north and north-west from the lava sheet, which also fed the Craig lava pipe; it is a very vesicular glassy basalt, with sparse olivine and larger augites.

Lava-flow from north of Fo-luk west-south-westward just south of "747 foot" hill. An olivine basalt with large augites.

Harbour Crater—from the trough formed by the explosion at Lon-wol-wol; a very vesicular glassy augite basalt.

South-east of Mt. Marum, from the vent of January 1, 1914, which formed the large lava sheet on the high plain to the south of Mts. Marum and Benbow, and fed the Port Vato lava pipe. Glassy olivine basalt with augite.

The typical rock of the 1913 eruptions, as represented in Mr. Frater's collection, is a basic lava, rich in black glass, and containing glomero-porphyritic groups of a basic felspar, which Mr. Tyrrell has determined as $Ab_3\ An_7$. The larger phenocrysts show zonal structure and are often deeply corroded. The groundmass is sometimes a dense black glass, and at others consists mainly of felspar laths with granules of augite and olivine. The olivine is usually in small grains, often enclosed in the radial groups of felspar, but it is sometimes in well-developed crystals. The proportion of olivine is small and in some sections none were observed.

Mr. Tyrrell has kindly examined the sections, and describes them as follows:—

"With the exception of slide D [from south of hill 747, west of Fo-luk] all the rocks consist of the same olivine-poor basalt, and differ only in texture, amount of glass, and vesicularity. In general the phenocrysts are comparatively sparse and small. They consist of plagioclase, augite, and olivine, named in order of abundance. The felspar is basic labradorite ($Ab_3\ An_7$), and is developed in curious little glomeroporphyritic groups with one or two crystals of olivine, rarely with augite. The augite is a yellowish-green diopsidic variety with extinction 40°. The groundmass, when dominantly crystalline, consists of granular augite and magnetite, with lathy felspars ($Ab_1\ An_1$). The augite + magnetite $\geqq$ felspar — a basaltic type of groundmass. Many of the rocks, however, contain a considerable amount of dark glass and are highly vesicular. In these glassy and vesicular varieties the felspar-phenocrysts appear to become more abundant relative to augite and olivine; and the olivine occasionally appears as tiny euhedral crystals in the groundmass. A very rough

estimate of relative proportions in the most nearly holocrystalline varieties is—

Phenocrysts, 8 per cent.	
Labradorite (Ab_3 An_7)	5
Augite	2
Olivine	1
Groundmass, 92 per cent.	
Labradorite (Ab_1 An_1)	30
Augite	45
Magnetite	5
Glass + cryptocrystalline material	12

"Augite is decidedly more abundant in slide Bd [from the west end of the lava sheet east of Craig Cove] than in others of the same rock.

"Slide D is an olivine-basalt with much more abundant phenocrysts than the above. Olivine and augite occur in large crystals only slightly inferior to the felspar in quantity. Phenocrysts slightly < or = groundmass.

"The rocks are certainly basalts (olivine-basalts) in the modern acceptance of this term. The distinction between basalts and andesites is now made to rest more on the relative proportions of light (felsic) to dark (mafic) constituents rather than on the nature of the plagioclase or the presence or absence of olivine. The andesites have a decided predominance of felspars over ferromagnesian minerals, and the felspars are usually, though not necessarily, andesine or acid labradorite. The basalts are characterized by approximate equality of felsic and mafic constituents, and generally by basic plagioclase and presence of olivine. Thus one may have olivine-andesites with phenocrysts of basic plagioclase (a type very common in the circum-Pacific volcanoes), and basalts devoid of olivine and containing only moderately basic felspars."

The specimens collected by Professor Davis from Dip Point (Marshall, 1915, p. 391) and those brought by Mr. Frater from Harbour Crater agree in character with those from the lava streams discharged from the fissures at Fo-luk. They are all basalts of the same type. Hence the explosive or non-explosive nature of the eruption at Ambrym must depend, not upon the nature of the rock, but upon the conditions of its eruption, and probably on the character of the surface into which it was intruded.

Professor Lacroix refers to the specimens he examined as too poor in olivine to be true basalts, although they contained 5 per cent of olivine. This amount is above that in most of Mr. Frater's specimens, in which Mr. Tyrrell determined the percentage of olivine as only one. Professor Lacroix identified the specimens he investigated as andose. The identification is of course correct, but the name is inappropriate, since, according to Professor Iddings (e.g. 1913, ii, p. 615), andose is a basalt and not an andesite, the natural affinity suggested by the name. Probably the older Ambrym lavas associated with the more explosive eruptions of the prehistoric volcanic eruptions on the island may be andesites; but they are not represented in Mr. Frater's collection, which, as Mr. Tyrrell's note shows, contains nothing that can be called an andesite.

TABLE OF ANALYSES.

	New Hebrides.				Japan.		
	Ambrym lava, 1913.	Glomeritic Basalt-Porphyrite, Mau.	Chocolate lava, Tanna.	Scoriaceous lava, Tanna.	Olivine-bearing hypersthene Andesite, Sakura-jima.	Basalt, Hizen.	Andose, Goto Is.
	1	2	3	4	5	6	7
SiO_2	49·26	46·78	57·041	56·755	60·59	52·19	48·33
Al_2O_3	17·18	21·22	19·512	21·096	17·77	19·74	16·29
Fe_2O_3	5·47	4·63	5·499	4·521	1·23	4·72	3·24
FeO	6·10	6·17	2·714	3·021	5·59	6·28	8·73
MgO	4·28	4·30	none	trace	2·39	2·24	5·70
CaO	10·78	12·07	8·157	9·014	6·34	6·99	8·50
Na_2O	3·20	1·40	2·831	2·804	3·04	3·48	3·59
K_2O	1·76	·64	2·375	3·272	1·68	2·04	1·49
TiO_2	0·89	1·20	—	—	0·71	—	2·40
P_2O_5	0·37	·31	—	—	0·08	—	·79
H_2O at 105°	0·12	1·44	·201	·241	0·59	1·25	·82
,, at red heat	0·90				0·23		
MnO	—	trace	2·053	trace	0·24	incl. ·06	·11
Cr_2O_3	—	·05	—	—	—		
SO_3	—	—	—	—	0·23		
	100·31	100·21	100·383	100·724	100·71	98·99	99·99
Quartz	—	—			16·81	3·2	—
Felspar	64	59			64·74	73·3	63·2
Diopside	22	24 (pyroxene)			0·28	2·1	11·0
Hypersthene	—	—			14·33	12·2	2·7
Olivine	5	10			—	—	11·5
Magnetite and Ilmenite	9	7			3·14	6·7	9·2

1. Boiteau, in Lacroix, 1914, p. 493.
2. Mawson, 1905, p. 470.
3. Liversidge, 1887, p. 236.
4. Liversidge, 1887, p. 237.
5. S. Tanaka, in Koto, 1916, p. 180.
6. Ono, quoted in Iddings, 1913, p. 615.
7. Yokoyama, quoted in Iddings, 1913, p. 615.

6. General Relations of the Ambrym Eruptions.

Notwithstanding the small eruptions on Ambrym which appear to have occurred throughout the nineteenth century, its volcanoes appear to have been comparatively quiescent between about 1820 and 1880. Then, as its share in the period of more active vulcanism which was begun by the Krakatoa eruption in 1883, and the explosion of Tarawera in New Zealand in 1886, Ambrym suffered from the violent eruptions of 1894 and 1913. This period has been marked in the circum-Pacific area by the following eruptions.

The series of great circum-Pacific eruptions began with the explosion of Krakatoa in 1883, and of Tarawera, New Zealand, and

Niauafau in the Tonga Islands in 1886. In 1894 was the first great eruption of Ambrym since about 1820; in 1902 began the eruptions of Savaii, which were repeated in 1905 and 1906; in 1902 happened the explosive eruptions of Mts. Collima and Santa Maria in Central America, followed by those of Mts. Pelée and St. Vincent in the Atlantic border of the West Indian area; in 1906 occurred the eruptions of Topia and Fanua-lai; in 1908 that of Puna in Hawaii, and in 1909 that of Korintzi, Sumatra; in 1912 the explosion of Katmai in Alaska caused sunset glows in Europe; Sangir Island, on the edge of the Pacific, between the Philippines and Celebes, broke into eruption in March, 1913, followed by that of Ambrym in December of the same year.

The two eruptions with which it is natural to compare the Ambrym outbreak of 1913 are that of Tarawera, which it resembles by the formation of a volcanic trough by explosions along a fissure, and that of Sakura-jima in Kyusu, Southern Japan, in 1914. That eruption was practically contemporary with the outbreak of Ambrym, and it has been described in detail by Professor Koto (1916, 1 and 2). It began towards the end of 1914 with small earthquakes and with eruptions from Kirishima, 34 miles north of Sakura-jima, in November and December, 1913; on January 12, 1914, Sakura-jima was devastated by an explosive eruption which lasted for nine hours; it began from the high central crater of the island, followed by the opening of two vents on the flanks of the island, the three vents being situated on a line running approximately east and west. Lava streams flowed from these vents, and one stream crossed the Strait of Seto and thus converted the island of Sakura-jima into a peninsula. The composition of the Sakura-jima lava is shown by the analysis, No. 5 on the table, p. 14; it is an andesite, though it contains small quantities of corroded and partially resorbed olivine. Professor Koto states that when he first saw the eruption he considered that the three linear vents were along one fissure traversing the island, and he says that the belief in such a fissure is universal (Koto, 1916, 2, p. 138). He has, however, himself come to the conclusion that the evidence for this fissure is not convincing. He regards Sakura-jima as built up around three centres, and that the recent eruption found outlets at the weakest points, as determined by the compound structure of the island. The fact that these were linear he apparently regards as a coincidence. In an interesting transverse section through the island he explains the recent eruption as discharging a central chamber partly through a vertical central pipe, but mostly through the lateral outlets at lower levels. There appears nothing inconsistent in this arrangement with the determination of the position of the lateral and central vents by a plane of weakness along an east and west fissure. The existence of such a fissure can only be a matter of conjecture as regards Sakura-jima, but the evidence for it at Ambrym appears conclusive.

7. References.

Beresford (C. W. de la Poer). 1884. "Note on the Ascent of Ambrym Volcano in the New Hebrides": Proc. Roy. Geogr. Soc., vol. vi, pp. 129–32.

CHAPMAN (F.). 1905. "Notes on the older Tertiary Foraminiferal Rocks on the West Coast of Santo, New Hebrides": Proc. Linn. Soc. N.S. Wales, vol. xxx, pp. 261–74, pls. v–viii.

FREDERICK (Lieut. G. C.). "Geological Notes on certain Islands in the New Hebrides": Quart. Journ. Geol. Soc., vol. xlix, pp. 227–9. Appendix I, "Volcanic Rocks from the New Hebrides," by J. J. H. Teall, pp. 229–30. Appendix II, "The Microscopic Structure of some of the Organic Rocks from the New Hebrides," by G. J. Hinde, pp. 230–1.

IDDINGS (J. P.). 1913. *Igneous Rocks*, vol. ii: xi, 685 pp.

KOTO (B.). 1916. 1. "Characteristics of the Eruption of Sakura-jima in 1914": Journ. Geol. Soc. Tokyo, vol. xxiii, No. 278, pp. 181–204; No. 279, pp. 205–26. 2. "The Great Eruption of Sakura-jima in 1914": Journ. Coll. Sci. Tokyo, vol. xxxvii, pt. iii, pp. 237, 24 pls.

LACROIX (A.). 1914. "La récente éruption d'Ambrym (décembre, 1913), et la constitution des laves de ce volcan": C.R. Acad. Sci., vol. clix, pp. 489–95.

LIVERSIDGE (A.). 1887. "On the Composition of some Pumice and Lava from the Pacific": Journ. Roy. Soc. N.S. Wales, vol. xx, pp. 235–9 (read December, 1886).

MARSHALL (P.). 1915. "The recent Volcanic Eruptions on Ambrym Island": Trans. New Zealand Inst., vol. xlvii, pp. 387–91.

MAWSON (D.). 1905. "The Geology of the New Hebrides": Proc. Linn. Soc. N.S. Wales, vol. xxx, pp. 400–85, pls. xiv–xxix.

PUREY-CUST (H. E.). 1896. 1. *Report on the Eruption of Ambrym Island, New Hebrides, S.W. Pacific*, October and November, 1894, Hydrographic Department, Admiralty, 2 maps, 5 pls. 2. "The Eruption of Ambrym Island, New Hebrides, S.W. Pacific, 1894": *Geogr. Journ.*, vol. viii, pp. 585–602, map opposite p. 656.

—— *Pacific Islands*. 1908. Vol. ii, 4th ed.: xxiv, 463 pp.

II.—The so-called Coprolites of Ichthyosaurians and Labyrinthodonts.

By Arthur Smith Woodward, LL.D., F.R.S.

(PLATE XXXIV.)

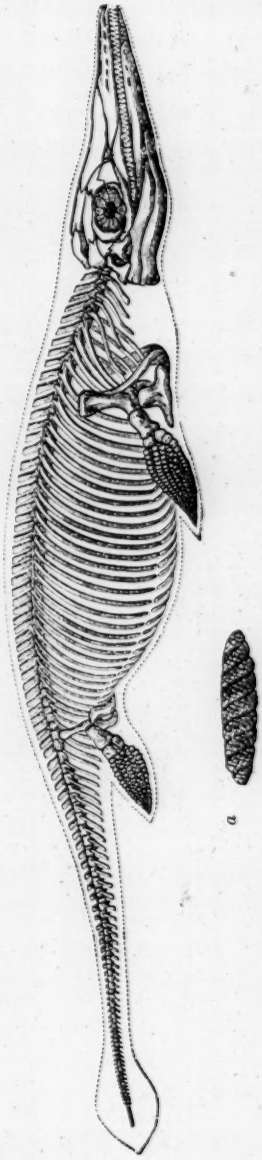
IT appears to be still generally supposed that the Ichthyosaurians differed from all modern reptiles in having a short intestine with a spiral valve, like that of the more generalized fishes; and the supposition is rendered all the more plausible by the common belief that some at least of the Labyrinthodonts were similarly characterized. In each case, it is true, coprolites or masses of partially digested food, marked with the line of an intestinal spiral valve, are often found in the same strata as the skeletons; but, so far as I have been able to discover, no instance is known in which the spirally-marked coprolite actually occurs in its natural position in the fossilized animal.

When Buckland first recognized the nature of coprolites he observed that the spiral form resembled that of the intestinal contents of a shark or skate[1]; but those of the shape in question occurred so abundantly with the skeletons of marine reptiles in the Lower Lias of Lyme Regis, that he felt no hesitation in referring them to the latter. In fact, he wrote: "The certainty of the origin I am now assigning to these Coprolites is established by their frequent

[1] W. Buckland, "On the Discovery of Coprolites, or Fossil Fæces, in the Lias at Lyme Regis and in other Formations": Trans. Geol. Soc. [2], vol. iii, pp. 223–36, pls. xxviii–xxxi, 1829.

presence in the abdominal region of the numerous small skeletons of Ichthyosauri, which, together with many large skeletons of Ichthyosauri and Plesiosauri, have been found in the cliffs at Lyme, and supplied to various collectors by the skill and industry of Miss Mary Anning. I have two of these skeletons, in each of which the Coprolites are very apparent, *but flattened*." The last remark (here italicized) is especially noteworthy, because it is evident that Buckland himself had not observed the spirally-marked form actually within the skeleton. As proved by his figures in the *Bridgewater Treatise* (pls. xiii, xiv), he had only seen the same kind of partially digested food which often occurs in well-preserved specimens.

In the Lower Lias of Lyme Regis, indeed, the remains of large sharks (*Hybodus* and *Acrodus*) are as abundant as those of marine reptiles. I am therefore inclined to refer the problematical coprolites to these fishes, in which they would be normal, rather than to the Ichthyosaurians, in which they would be abnormal. Professor Eberhard Fraas has already arrived at the same conclusion in his well-known work on Ichthyosauria.[1] He points out that the spirally-marked coprolites do not always occur in the same deposits as the Ichthyosaurian skeletons, and that most of them, at any rate, probably belong to fishes, especially Selachians. That the short intestine with a spiral valve has always characterized the sharks is shown by its beautiful preservation in a specimen of the Devonian *Cladoselache* in the British Museum, drawn in Plate XXXIV. Here there can be no doubt about the interpretation of the appearances in the fossil, such as exists in reference to one



Restoration of a skeleton of *Ichthyosaurus* from the Lower Lias of Lyme Regis, with a spirally-marked coprolite (*a*) beneath, as published in Owen's *Palæontology*, 1860-1, p. 221.

[1] E. Fraas, *Die Ichthyosaurier der süddeutschen Trias- und Jura-Ablagerungen*, p. 34 (Tübingen, 1891).

of the ganoids from the Bavarian Lithographic Stone, *Asthenocormus* [*Agassizia*] *titanius*.[1]

Assuming that Buckland's determination of the coprolites of *Ichthyosaurus* was correct, Gaudry[2] seems to have been the first to ascribe similar coprolites to a Labyrinthodont. He was then followed by von Ammon[3] and Neumayer.[4] In these cases again, however, the coprolites and skeletons were merely found in the same stratum, the one fossil never actually within the other. Though coprolitic matter is sometimes seen in the common *Archegosaurus* and other genera, it has never been observed to exhibit the spiral impression. Indeed, the only Labyrinthodont—a small Branchiosaurian—in which the whole course of the alimentary canal has been clearly distinguished, agrees in its digestive arrangements with an ordinary salamander.[5] Fritsch was therefore probably right when he concluded[6] that the coprolites bearing marks of a spiral valve, found in the same strata as the Labyrinthodonts, could scarcely belong to these animals, but must rather be referred to the associated selachian and ganoid fishes.

There is thus no reason for believing that either the earliest Amphibians or the earliest Reptiles retained the peculiar structure of the intestine which characterized the ancestral Fishes.

EXPLANATION OF PLATE XXXIV.

Ventral view of a shark (*Cladoselache clarki*) from the Upper Devonian of Berea, Ohio, U.S.A., showing the intestine (*int.*) with a spiral valve, filled with partially digested food; one-sixth nat. size. British Museum, No. P. 9271.

III.—On the Unconformity between the Cretaceous and Older Rocks in East Kent.[7]

By Herbert Arthur Baker, B.Sc., F.G.S.

(WITH TWO MAPS AND SECTION IN TEXT.)

In a previous paper[8] the writer briefly alluded to the evidence, as known from the deep borings in East Kent, afforded by the Palæozoic and Mesozoic rocks, of the operation of a posthumous

[1] B. Vetter, Mittheil. k. mineral.-geol. Mus. Dresden, pt. iv, p. 105, 1881; C. R. Eastman, Mem. Carnegie Mus., vol. vi, p. 416, 1914.

[2] A. Gaudry, "L'Actinodon": Nouv. Archiv. Mus. d'Hist. Nat. Paris, ser. II, vol. x, p. 19, text-fig. 8, 1887.

[3] L. von Ammon, *Die permischen Amphibien der Rheinpfalz*, p. 102, pl. iv, fig. 4 (Munich, 1889).

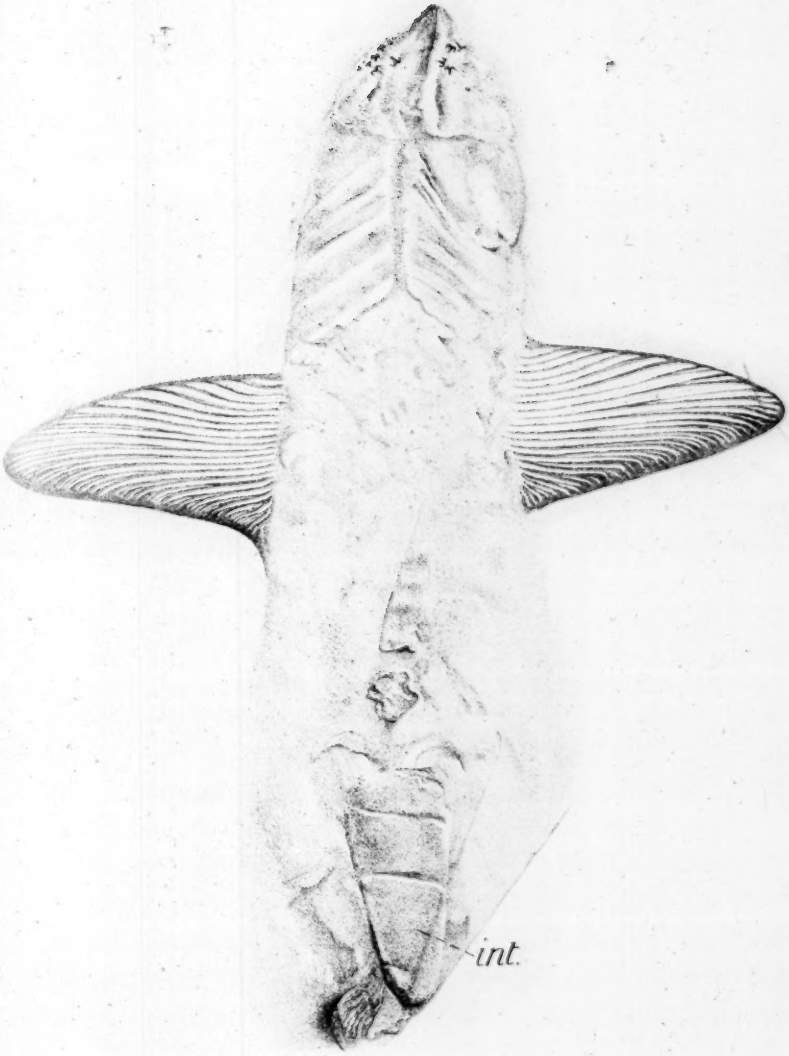
[4] L. Neumayer, "Die Koprolithen des Perms von Texas": *Palæontographica*, vol. li, pp. 121–8, pl. xiv, 1904.

[5] R. L. Moodie, "The Alimentary Canal of a Carboniferous Salamander": *Amer. Nat.*, vol. xliv, pp. 367–75, with figs., 1910; also *The Coal Measures Amphibia of North America*, pp. 26, 59, figs. 7, 14, Carnegie Institution, 1916.

[6] A. Fritsch, *Fauna der Gaskohle*, etc., vol. ii, p. 59, 1885.

[7] [This article and its illustrations were sent by the author to the Geological Magazine on September 27, 1917, and set up in type on October 9, but publication was deferred through want of space until this month. The author has sent a brief note, dated, at sea, November 14, which has been inserted at the end of his paper (see p. 549).—Ed.]

[8] Geol. Mag., Dec. VI, Vol. IV, No. 639, September, 1917, pp. 398–403.



FOSSIL SHARK, Upper Devonian.
OHIO, U.S.A.

axis of unrest, probably of Charnian affinity. This conception receives further support from a study of the special characters exhibited by the Wealden of East Kent and the nature of the unconformity between these strata and the Mesozoic and Palæozoic rocks underlying them.

When the composition of the sub-Cretaceous surface in East Kent is investigated it is seen to consist, in the north-east, in the neighbourhood of Walmestone, Mattice Hill, and Ebbsfleet, of Palæozoic rocks (Middle Coal-measures). A little to the north of Ebbsfleet, in the vicinity of Ramsgate, the sub-Cretaceous surface must be composed of the outcrop of the Carboniferous Limestone. South-westward of the outcrop of Middle Coal-measures, in the neighbourhood of a N.W.–S.E. line passing through Stodmarsh, occurs an area where the surface is composed of Bathonian. There can be no doubt that these Bathonian strata once extended further north-east and were overlapped in their turn by the Oxfordian, Corallian, and Kimmeridgian (see Section, p. 548), but these Upper Jurassics, and the Bathonian itself in part, have been removed by the severe pre-Cretaceous and early Cretaceous denudation to which the East Kent area was subjected. This sub-Cretaceous outcrop of the Bathonian is followed south-westward successively by outcrops of the Oxfordian, Corallian, and Kimmeridgian. In the south and west, westward of Ellinge, the Portlandian follows the Kimmeridgian in normal sequence, but makes no feature at the sub-Cretaceous surface owing to its being concealed by an overlap of the Purbeck. It appears likely that this overlap is an unconformable one. At Dover the coarse, freshwater Wealden gravels rest directly upon an irregularly worn surface of Kimmeridge Clay, but Mr. Lamplugh considers that there is at least a strong probability that marine sedimentation continued in this area into Portlandian times, though it is less likely that the Purbeck Series was ever developed here.[1] At Ellinge the Portlandian is missing, the Purbeck resting directly on the Kimmeridgian. It would appear, then, that the Purbeck cuts across the Portlandian on to the Kimmeridgian in this area. Further, at Brabourne the Purbeck strata comprise clays and sands with a strong green tint (perhaps due to the presence of glauconite, which is so often associated with non-sequential deposition), and contain also a remarkable breccia of peculiar composition, similar in character to that seen in the Purbecks of Hartwell, Bucks, and elsewhere, the occurrence of which appears to be associated with local unconformities.

It is unfortunate, from the point of view of the cartographer, that so many of these borings in East Kent were made by chisel, and that there is, in several instances, doubt concerning the precise sequence in the Jurassic strata passed through. It is beyond doubt, too, that this area has been largely affected by faulting, and the application of cartographical methods to the available data becomes in consequence a matter for careful consideration. It does not appear possible, in the present state of our knowledge, to do more than show the positions

[1] Lamplugh & Kitchin, *On the Mesozoic Rocks in some of the Coal Explorations in Kent* (Mem. Geol. Surv., 1911, p. 20).

of the various belts of Jurassic strata, and indicate, in a general way, the approximate positions of certain boundaries. This is done in Map below, Fig. 1.

In a general way, then, it can be seen that the deposition, subsequent upheaval and denudation, and imparted strike and dip of

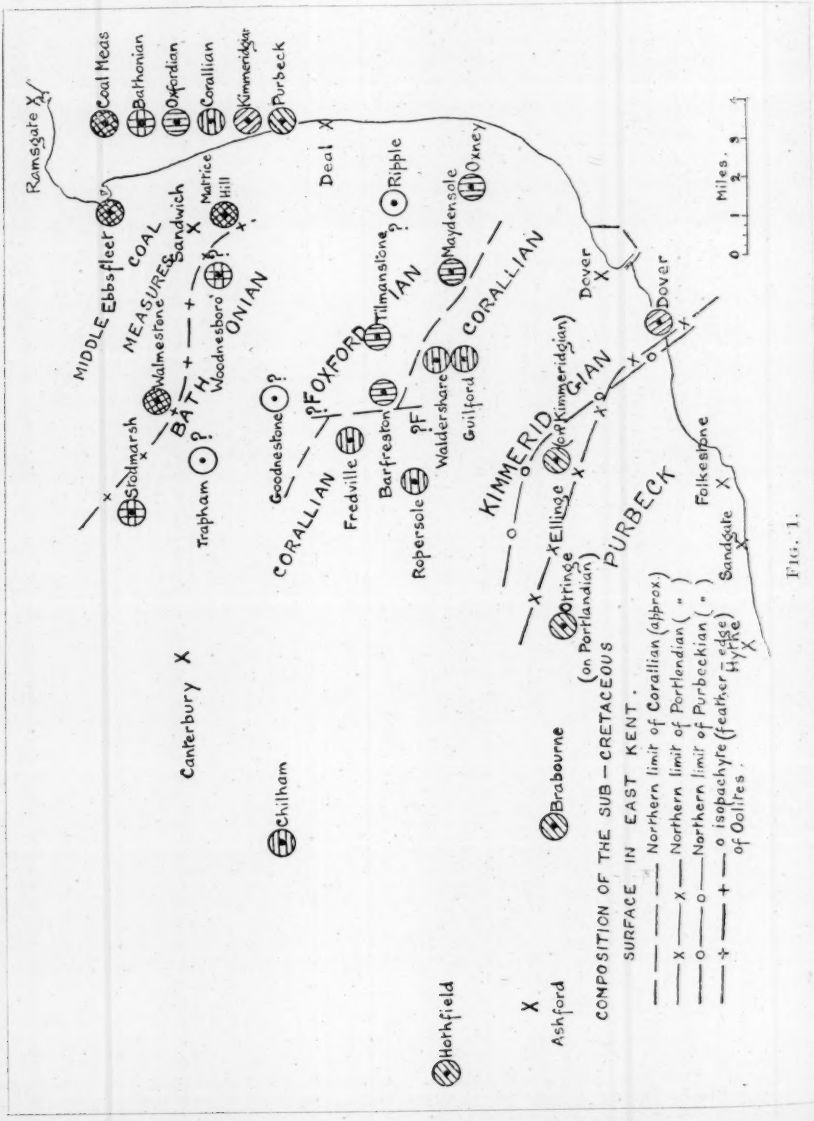


FIG. 1.

the Jurassics of East Kent are distinctly related to the movements of an axis of unrest lying to the east and north of Kent and possessing a N.W.–S.E. alignment.

Further west in Kent the Bobbing boring showed the sub-Cretaceous surface to be composed of Oxfordian strata, as did also that at Chatham Dockyard, thus demonstrating that the Oxfordian outcrop pursues the same general north-westerly or west-north-westerly direction for a considerable distance.

A point of interest concerning the position of the northward limit of the Corallian outcrop in East Kent may be noted. It will be observed that the line passes south of Oxney and Maydensole, north of Waldershare, and south of Barfreston, and then turns sharply northward in the neighbourhood of the Snowdown sinking (between Fredville and Barfreston) and resumes its general north-westerly course northward of Fredville. This deflection may perhaps be due to proximity with some anticlinal disturbance, but is more probably the indication of a pre-Cretaceous dip-fault here, possessing a westerly downthrow, which has resulted in a lateral displacement of the outcrops southward on the eastern side of the fault. In this connexion it is interesting to recall the anomalous dip of the Coal-measures observed at the Snowdown Colliery, where, instead of a dip of about 3° in a direction 35° west of south, as observed in the Tilmanstone Colliery, one of 2½° in a direction 20° north of east was found. It appears likely that faulting may have taken place here in consequence of the occurrence of a sagging movement in the south-west during deposition under isostatic conditions (see below).

The denudation of the sub-Cretaceous surface in East Kent obviously reached an advanced stage, and the area must have been reduced almost to a smooth peneplain before the deposition of the Wealden upon it. Probably, too, in earliest Cretaceous times the peneplain was corraded to some extent by stream action prior to the commencement of deposition, but not sufficiently so to produce any very marked variations in level upon it. If we eliminate the effects of post-Lower Cretaceous movements from the area by correcting the present base of the Gault here to a datum-plane at Ordnance Datum and consider the levels of the base of the Wealden in relation to it, the latter is seen to present the form of a plain possessing a very gentle southerly slope, the difference in level between the highest and lowest points upon it being less than 200 feet.

Seeing that in East Kent "the strata between the Oxford Clay and the main limestones of the Great Oolite Series . . . appear to represent a continuous sequence of marine deposits",[1] and also that "the deposition of clayey sediments went on uninterruptedly from Oxfordian to Kimmeridgian times",[1] the advanced stage to which the denudation attained is at first sight surprising, but on reflection it will be seen that denudation in the north-east must have been contemporaneous with deposition in the south-west during the latter part of Jurassic times. The general movement of uplift of the British region in Portlandian times must have exposed to denudation an area of Kimmeridge Clay fringing the Palæozoic ridge in the

[1] Lamplugh, loc. cit.

north-east while deposition of Portlandian sediments was in progress in the south-west. This state of affairs persisted into Purbeckian times, and was probably accentuated by differential movement. Direct posthumous uplift along the axis may have occurred in post-Portlandian times, but it seems likely that we have in East Kent, on the western flank of the ancient ridge, an illustration of the operation of the principle of isostasy, a sagging of the area of deposition in the south-west, under the weight of the great accumulation of Jurassic strata, being compensated by concomitant uplift in the north-east. Differential movement of this character was apparently taking place in Purbeckian times, for although the Purbeck appears never to have extended far to the north-east, yet it transgresses on to the Kimmeridgian.

Passing on now to consider the character of the Cretaceous rocks which overstep the successive members of the Jurassic until they rest upon the Palæozoic floor, the writer ventures to remark that it would probably be difficult to find a happier illustration of the utility of constructing maps of isopachyte systems of strata than that afforded by the Wealden of East Kent. The isopachytes are found to throw a very interesting light upon the question of the conditions under which these strata were deposited (see Map 2).

It is immediately apparent that the isopachytes are of a character very different from that possessed by those of a marine formation. They are clearly the lines of an estuarine deposit, and indicate plainly that the Wealden of East Kent was deposited by a river flowing from the north-east. In the view of the writer this river was consequent upon the easterly Charnian ridge. South of Woodnesborough it appears to have divided into two streams which turned south-east and flowed as subsequent or strike streams into the Wealden lake. The southerly slope of the land being now exceedingly gentle in the East Kent area, in consequence of much levelling up having been effected by the steady accumulation of great wedge-like masses of Mesozoics to the south-westward, local conditions became significant in deciding the course of the streams when the influence of the primary ridge began to die out with distance. The course of one stream appears to have been determined to some extent by the Snowdown disturbance, and it appears to have selected the Oxford Clay outcrop for some distance in preference to the harder Corallian limestones. Similarly, the more westerly stream appears to have selected the outcrop of the Kimmeridge Clay, and the erosion of the later Jurassics from the Dover area was doubtless due to its agency.

It is interesting to consider the nature of the Wealden sediments in the light of the information afforded by the map. Mr. Lamplugh, in the Survey memoir,[1] has expressed the opinion that the Wealden section in the Dover shafts offers strong indication of the inflowing of a river from the north-east. The present map shows the correctness of this view. He expresses surprise, however, at the seeming lack of Mesozoic material among the Wealden sediments, in view of the fact that such a river must have crossed an area of ancient

[1] Lamplugh, loc. cit.

quartz-veined rocks ringed round by Mesozoic formations. A little consideration will now show that such a seeming absence of Mesozoic débris need occasion no surprise. That the river must have flowed over bare Palæozoic rocks during by far the greater part of its course is quite obvious, for this area of bare Palæozoic extended (in Wealden times) as far to the south-west as Walmestone and Deal, and the river did not arrive at the neighbouring Mesozoic area until it had attained its lower reaches. Nevertheless this apparent absence of Mesozoic material from the Wealden sediments can be

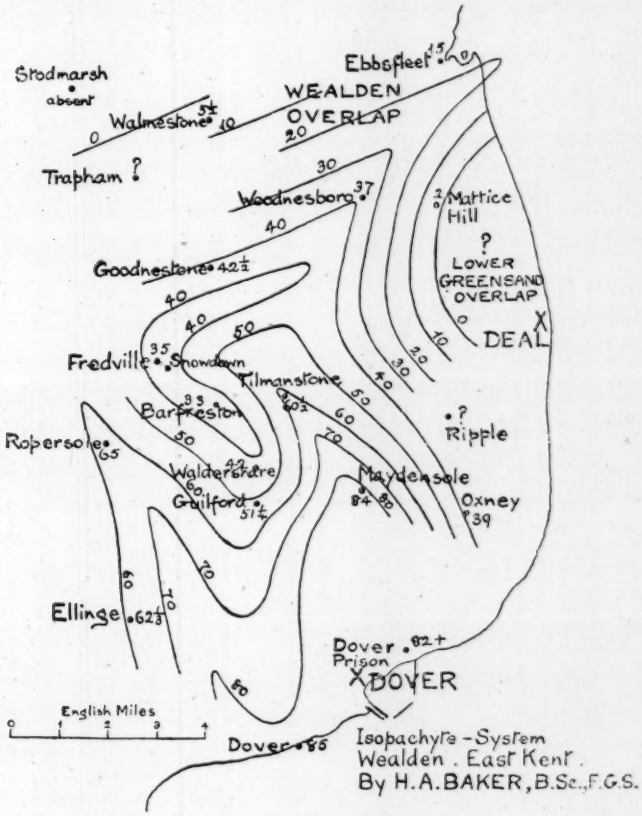


FIG. 2.

only a seeming one. Mesozoic débris must be there, but its presence is doubtless masked by the preponderance of the ancient quartzose rocks. The river must have possessed greater velocity during the earlier part of Wealden times, in view of the steady movement of submergence which was taking place, and from the character of the Hastings Beds in East Kent it can be seen that the abrading and transporting power of the stream in this area must have been considerable, only the coarser portion of its burden having been deposited

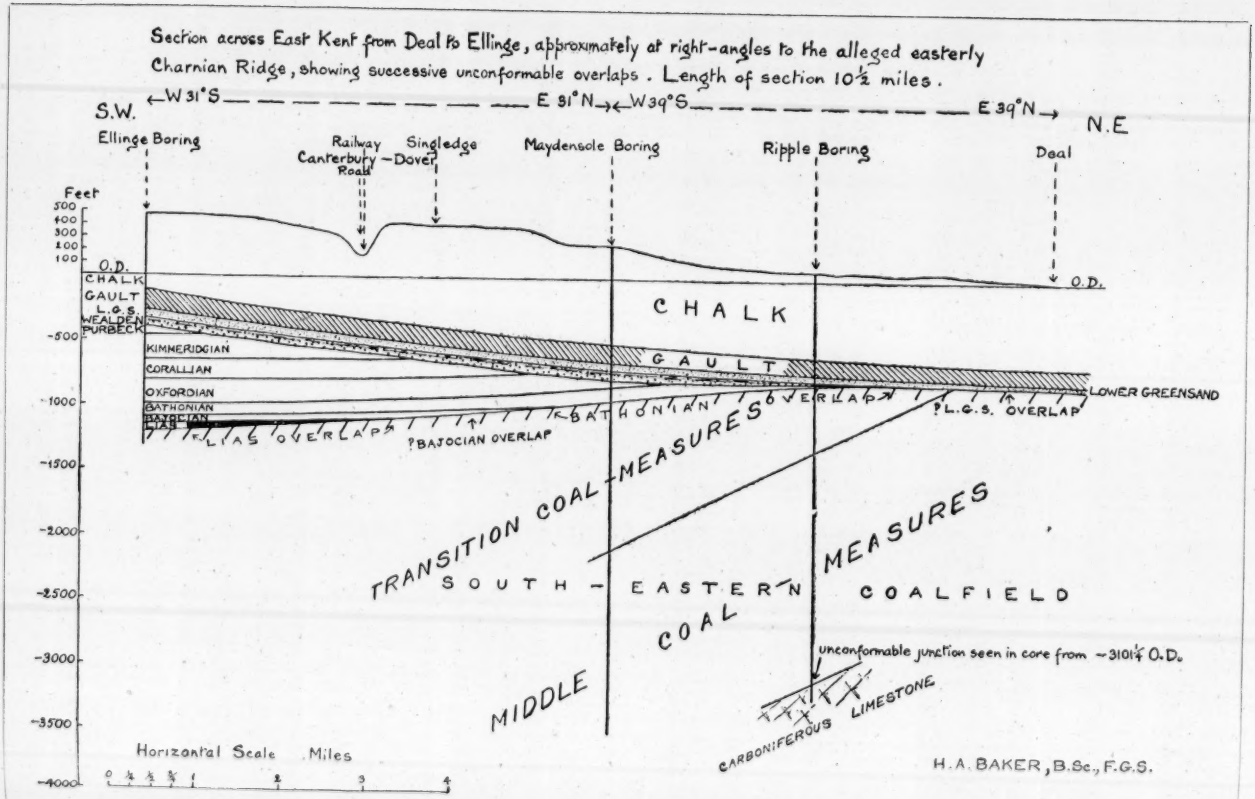

Section across East Kent from Deal to Ellinge, approximately at right-angles to the alleged easterly Charnian Ridge, showing successive unconformable overlaps. Length of section 10½ miles.
←W 31°S — — — — — — — — — — E 31°N→←W 39°S — — — — — — — — — — E 39°N→
S.W.
N.E
Ellinge Boring
Railway Canterbury—Dover Road
Singledge
Maydensole Boring
Ripple Boring
Deal
Feet
500
400
300
200
100
O.D.
CHALK
GAULT
L.G.S.
WEALDEN
PURBECK
-500
-1000
-1500
-2000
-2500
-3000
-3500
-4000
KIMMERIDGIAN
CORALLIAN
OXFORDIAN
BATHONIAN
BAJOCIAN
LIAS
LIAS OVERLAP
?BAJOCIAN OVERLAP
BATHONIAN OVERLAP
?L.G.S. OVERLAP
O.D.
CHALK
GAULT
LOWER GREENSAND
TRANSITION COAL-MEASURES
SOUTH-EASTERN COALFIELD
MIDDLE COAL MEASURES
unconformable junction seen in core from -310¼ O.D.
CARBONIFEROUS LIMESTONE
Horizontal Scale Miles
0 ¼ ½ ¾ 1 2 3 4
H.A. BAKER, B.Sc., F.G.S.

Fig. 3.

here. The finer portion must have been dropped further on in its course. Possessed of this corrasive power in East Kent, erosion of the Mesozoic area of its bed must have been inevitable, but doubtless the finer part of the eroded material was carried beyond the area. Rarity of Mesozoic débris is therefore to be expected in the Wealden of East Kent, and where Mesozoic fragments do occur they are probably of large size and marked angularity. Comparison of the details yielded by some of the borings suggests that the Mesozoics in East Kent underwent erosion in early Wealden times, although it must be borne in mind that allowance must be made for the general pre-Cretaceous denudation of the area. For example, the sites of the Tilmanstone shaft and the Barfreston boring both lie on the sub-Cretaceous outcrop of the Oxfordian, and since Tilmanstone lies a little to the north-east of Barfreston we should expect the thickness of Oxfordian passed through to be rather less there. In actuality, only 3 feet of Oxford Clay remain at Tilmanstone, whereas 102 feet were passed through in the Barfreston bore. It would appear, then, that the early Cretaceous strike-stream which traversed the outcrop of the Oxford Clay in the neighbourhood of Tilmanstone was responsible for a considerable amount of erosion.

With continued submergence Weald Clay times approached, and delta conditions, ushering in the marine invasion of the Lower Greensand, began to prevail. The waters of the Wealden lake encroached northward upon East Kent, the velocity of the streams was checked, finer sediments began to be deposited in quantity, and base-level conditions were realized. The spreading waters united the streams into a single sheet. The evidence shows that the main stream and its two subsequent branches had become united into a single sheet of water before the commencement of Weald Clay times. Higher ground, separating the two subsequent streams from each other, appears to have existed in the neighbourhood of Fredville, yet 28½ feet of Hastings Beds occur here. To the north-east, however, the velocity of the stream still remained such that deposition had not yet commenced. Probably in this area the stream was active in removing from the Palæozoic floor some of its Bathonian covering. With the advent of Weald Clay times, however, deposition proceeded over the whole area under water, and the surface so long exposed to denudation was finally buried. In the neighbourhood of Deal a small area of Coal-measures remained uncovered until Lower Greensand times, and at and near Stodmarsh an area of Bathonian remained until Gault times.

Note.—After the proofs of this paper had been sent to the Editor additional information became available in consequence of the publication of the *Summary of Progress of the Geological Survey for 1916* (Mem. Geol. Surv. 1917). Details concerning three additional borings (J. Pringle, Appendix II), viz., at Bere Farm (1¾ miles north-east of Dover), Elham (close to Elham Station), and Folkestone, are now to hand. The Bere Farm boring shows the sub-Cretaceous surface there to be composed of Corallian Limestone, as was expected, although the thickness of the Wealden (42 feet) is

less than might have been expected. The Elham and Folkestone borings show the south-westerly thickening of the Wealden (153 feet and 218 feet respectively), but each apparently demonstrates the entire absence of both Purbeck and Portland rocks.

Mr. G. W. Lamplugh (Appendix IV) discusses the underground range of the Jurassic and Lower Cretaceous rocks in East Kent, and is more fortunately situated than the present writer (who has been away at sea) in having information furnished by a further twelve borings to work upon.

November 14, 1917.

REPORTS AND PROCEEDINGS.

I.—The Royal Society.

November 8, 1917.—Sir J. J. Thomson, O.M., President, in the Chair.

The following paper was read:—

"The Structure, Evolution, and Origin of the Amphibia. Part I: The 'Orders' Rachitomi and Stereospondyli." By D. M. S. Watson, M.Sc., Lieut. R.N.V.R. (Communicated by Professor J. P. Hill, F.R.S.)

In this paper all known genera of Rachitomous and Stereospondylous Stegocephalia are reviewed, the brain-case and basi-cranial region, hitherto practically unknown, being described more or less completely, and much new information about other regions set down. It is shown that there are a series of characters which change steadily with time in all Labyrinthodontia. The more important of these changes are—

1. The gradual reduction and final loss of basi-occipital, basi-sphenoid, and supra-occipital bones and cartilages.

2. The gradual replacements of basi-pterygoid processes of the basi-sphenoid by expansions of the para-sphenoid, and finally of the ex-occipitals with which the pterygoids articulate.

3. The gradual increase in size of the inter-pterygoid vacuities, and of the para-sphenoidal rostrum.

4. The gradual regression and final disappearance from the skull of a foramen for the hypoglossal nerve.

It is pointed out that these characters, which are seen to arise within these two groups, are those which have always been regarded as the diagnostic features of the class Amphibia, and that it is certain that they have arisen independently in at least three great orders.

Finally, it is shown that a hypothetical ancestor of the Rachitomi obtained by projecting backward the evolutionary trends shown in these and other series of characters which change regularly with time, is actually realized in the Embolomerous Amphibian *Pteroplax*.

II.—Geological Society of London.

November 7, 1917.—Dr. Alfred Harker, F.R.S., President, in the Chair.

The following is an abstract of a lecture on "The Nimrud Crater in Turkish Armenia" delivered by Felix Oswald, B.A., D.Sc., F.G.S.:—

The Nimrud volcano, one of the largest volcanic craters in the world, is situated on the western shore of Lake Van, and was surveyed and investigated geologically for the first time by the speaker in 1898. The western half of the crater is occupied by a deep lake of fresh water, while the eastern half is composed of recent augite-rhyolites, partly cloaked in white volcanic ash. The crater wall is highest on the north (9,903 feet), rising in abrupt precipices over 2,000 feet above the lake (7,653 feet). The southern wall is also precipitous, but only reaches the height of 9,434 feet (the south-eastern part). A large slice of the crater wall has slipped down on the south-west, so as to form a narrow shelf, 800 feet above the lake. The crater is nearly circular, 8,405 yards from west-south-west to east-north-east, while the transverse axis is 7,905 yards. The lowest points lie on the long axis, reaching only 8,139 feet on the western and 8,148 feet on the eastern rim.

The crater wall has an external slope of 33° on the south and east, where it consists exclusively of overlapping lenticular flows of augite-rhyolite and obsidian. On the south-west, west, north-west, and north these are capped by thin sheets of cindery basalt which must have possessed great fluidity, extending for many miles to form wide plains of gentle slope and great fertility down to Lake Van on the east and into the Plain of Mush on the west. These basalt-flows dammed up the north-east to south-west valley between the Bendimahi and Bitlis Rivers, and thus brought Lake Van into being.

The history of the Nimrud volcano may be summarized as follows from the speaker's observations:—

1. Its forerunner was the Kerkur Dagh on its southern flank—a denuded mass of grey augite-trachyte, rising to 9,000 feet, and crowned by many peaks. It was probably erupted in the Pliocene Period, subsequently to the folding of the Armenian area, in which the latest folded rocks are of Miocene (Helvetian–Tortonian) age, occurring north of the Nimrud Dagh and consisting of limestones with corals (*Cladocora articulata*, *Orbicella defrancei*, etc.), *Lithothamnion*, Foraminifera (Lepidocycline *Orbitoides*, *Amphistegina*, etc.), beds of *Pecten* (*P. urmiensis*, etc.) and of oysters (*Alectryonia virleti*). Nimrud and the other numerous volcanoes of Armenia came into existence at a period when the sedimentary rocks could no longer be folded, but were fractured along definite lines, and Nimrud is situated on the great fracture transverse to the Armenian folds at the apex of their bending round from the Antitauric (west-south-west to east-north-east) to the Persian (north-west to south-east) direction, and it also marks the point of intersection of this fracture with a great north-east to north-west fracture (Caucasian direction), which delimits on the south Lake Van and the faulted depression of the Plain of Mush, abruptly cutting off the Tauric horst of pre-Devonian marbles and mica-schists.

2. Numerous flows of augite-rhyolite built up the vast cone of the Nimrud Dagh, and the increasing pressure on the central vent became relieved by extrusions of augite-trachyte along radial fissures, forming the present promontories of Kizvag, Zighag, and Karmuch.

3. A presumably long period of inactivity was followed by violent explosions destroying the summit of the cone, and from this crater (smaller than the present one) vast lava-flows of a very fluid basalt (crowded with phenocrysts of labradorite, pale-green augite, and some olivine) flooded the country and filled up the Bitlis and Akhlat valleys, which have since then been eroded a little below their former depth. The Sheikh Ora crater of basic tuff (now breached by Lake Van) probably belongs to this period.

4. Further explosions widened the crater, in which a large lake was formed, while the eastern half of the crater became filled by a succession of outflows of augite-rhyolite, in which numerous blow-holes were drilled, bringing to the surface large blocks of basaltic agglomerate and also affording sections showing the transition downwards from obsidian, spherulitic obsidian, and spherulitic rhyolite to banded augite-rhyolite (with sanidine and green augite in a micropœcilitic ground-mass).

5. The last eruption was recorded in 1441 by a contemporary Armenian chronicler, and resulted in the extrusion of a very viscous augite-rhyolite along a north-to-south zone of weakness, both inside the Nimrud crater, where it separated off part of the large lake to form the shallow, so-called "hot lake", and also to the north of Nimrud, where it rose up fissures and in a small crater.

6. A violent earthquake in 1881, which destroyed the village of Teghurt, at the eastern base of the crater wall, was the last sign of activity; but earthquakes are still frequent in the Plain of Mush, at the western foot of the Nimrud Dagh, and recent fault-scarps are clearly visible along the borders of this faulted depression.

The speaker mentioned that he had presented his model of the crater to the Museum of Practical Geology (Jermyn Street) and the rocks and slides to the British Museum (Natural History), where his fossils from Armenia are already preserved.[1]

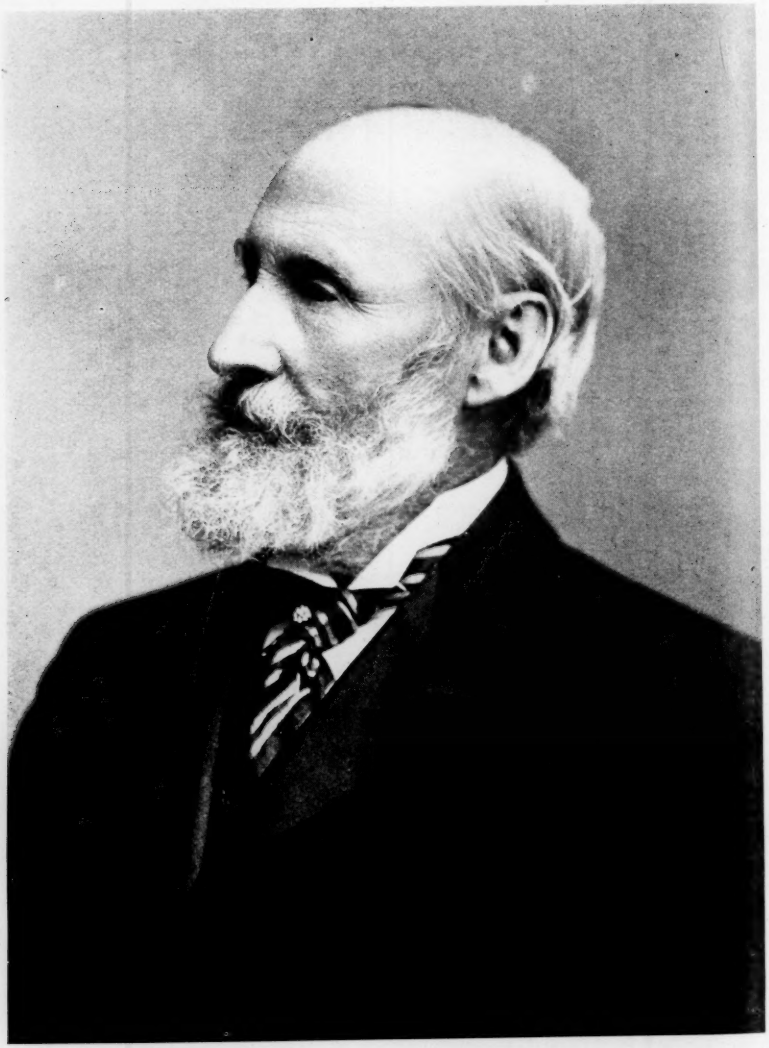
A short discussion followed, and the thanks of the Fellows present were accorded to Dr. Oswald for his lecture.

CORRESPONDENCE.

COAL IN THE SILURIAN AT PRESTEIGN.

Sir,—Mr. Cantrill's article in the November number of this Magazine on the boring for coal in Silurian and Longmyndian rocks at Presteign (pp. 481–92) is interesting in throwing light upon one of the most flagrant examples of the ignoring of geological evidence in exploits of this nature. As there must have been some grounds for the impression in the locality that coal existed there,

[1] Lantern-slides of many unpublished photographs and drawings of the Nimrud crater and its surroundings, a model coloured geologically (scale, 1 inch = 1 mile), and a series of rock-specimens and rock-sections were exhibited by Dr. Oswald in illustration of his lecture. A Geological Survey map of the Maclean Umtata district, Cape Province, Sheet 27, scale 3·75 miles = 1 inch, 1917 (presented by the Geological Survey of the Union of South Africa), was also exhibited.



Yours very truly

Edward Hull

without which local money probably would not have been forthcoming, I may mention that on a visit to the section last August, with Professor Garwood (whose excellent conjoint paper with Miss Goodyear, read at the Geological Society on June 6, and published in abstract in the Proceedings on June 13, 1917, has been overlooked by Mr. Cantrill in his account of work on the district), we learnt from an old quarryman, whose memory reached back many years, that it had been the custom in slack times to cart coal from the Clee Hills for lime-burning. In order to preserve the coal it was necessary to *bury* it, often in considerable quantities. Relics of these hoards are occasionally met with, and, as their history has been generally forgotten, it is very likely that these chance finds gave rise to the idea that coal-bearing beds exist in the locality.

W. W. Watts.

Hillside, Langley Park,
Sutton, Surrey.
November 12, 1917.

OBITUARY.

PROFESSOR EDWARD HULL, F.R.S.

(WITH A PORTRAIT, PLATE XXXV.)

Born May 21, 1829. Died October 18, 1917.

By the death of Edward Hull, in the 89th year of his age, another of the links has been broken which connect the geologists of to-day with those of the earlier half of last century. He was born in Antrim, and came of a stock that had been settled in Ireland for at least four generations. Educated at Trinity College, Dublin, he took his degree in Arts there. It was there, also, that he was inspired with a strong bent towards geology by the prelections of Professor Thomas Oldham. That eminent man gave him a letter of recommendation to Sir Henry De la Beche, Director-General of the Geological Survey, who without loss of time found a place for him in 1850 on his staff. From the time when Hull began field-work by running sections in North Wales under J. B. Jukes, he continued for seventeen years to be employed in England, first mapping tracts in Gloucestershire and the upper parts of the Thames Valley, and then in the coal-fields of Cheshire and Lancashire. During the winter months, when the members of the staff, quitting the field, repaired to London for indoor work in the office, Hull gained the good-will of his colleagues by his imperturbable good-nature, which, in sport, they would sometimes tax to its utmost limit. But he seemed never to bear any of them a grudge, taking it all as part of the routine of Survey life. They came to recognize that beneath his foibles of manner there lay a kindly heart, ever ready to respond to kindness.

In 1867, on the separation of the Geological Survey of Scotland as a special branch, Hull's good service was rewarded by his being

appointed District Surveyor and second in command on the Scottish branch. Stationed at Glasgow, he was entrusted with the mapping of the Clyde coal-field. But he had not been more than two years in this new sphere when he received further promotion by being appointed to succeed Jukes as Director of the Geological Survey of Ireland—a post which he continued to fill until he retired from official life, after a service of forty years.

The Irish Directorship was by no means a bed of roses. The staff included at least one fiery member, who, with characteristic Irish contempt for the ruling power, began opposition before the newly appointed official had set foot in Ireland, demanding that the appointment should be cancelled. When this demand was rejected, he commenced the same system of petty insubordination and opposition which had reduced poor Jukes to despair. Hull, however, as an Irishman, was probably not wholly unaccustomed to such tactics. He never succeeded in permanently silencing the malcontent, and made many an appeal to his chief in Jermyn Street for support. Indeed, no small part of his official correspondence with headquarters consisted in reports of fresh and unexpected devices of opposition. But his equanimity seemed never to be seriously ruffled. No higher testimony to his essential good-nature could be desired than the fact that he bore the perpetual worry for two and twenty years without losing either his wits or his temper. During his reign in Ireland he had the opportunity of seeing the geology of every part of the island. This wide experience gave him material for the preparation of a convenient new general geological map of the country on the scale of 8 miles to an inch. While discharging his duties in the Survey he also held the Professorship of Geology in the Royal College of Science in Dublin.

In 1891 Hull retired from official life. He was then little more than 60 years of age, and still in full possession of health and vigour. He determined to come to London and settle there in the expectation that he might find congenial employment as a practical geologist or geological engineer, especially in connexion with such matters as coal-mining and water-supply, in which he had often been consulted during his life on the Survey. He never allowed his pen to rust. The list of his memoirs, papers, and separate books is a monument of his industry. He was a voluminous writer on English geology from the beginning of his life in the Survey onwards. Some of his early papers are marked by a suggestiveness in the discussion of more or less theoretical questions which gave promise of distinction that was hardly fulfilled in his later work. His best known volume, *The Coal-fields of Great Britain*, is a useful compendium of the subject of which it treats, and has passed through five editions. Reference should also be made to his contributions to our knowledge of the geology of Palestine. He was sent to that country in 1883 by the Palestine Exploration Society, as leader of an expedition which included the future Lord Kitchener as one of its staff, the object of research being to report on the region of Mount Seir, Sinai, and Western Palestine. In later years he devoted much time to tracing on Admiralty and other charts the

submarine continuations of the river-valleys of Western Europe and Western Africa.

In 1910 the retired Professor published a thin autobiographical volume, entitled *Reminiscences of a Strenuous Life*. His career, like that of many other public servants, was quiet, uneventful, and not unsuccessful. It included sufficient leisure for such work as he chose to undertake, outside the sphere of his official duties, and of this leisure he diligently availed himself in the preparation of his contributions to the scientific literature of the time. Though much of his writing may not be enduring, it must be admitted that he has left his mark on the records of English geology.

Those who knew Edward Hull best will always remember him as a leal-hearted friend, who through a long life maintained the honour of a gentleman and carried with him cheerfulness and good will wherever he went.

A. G.

Note.—On June 1, 1914, Professor Hull was one of those friends who wrote and congratulated the Editor on the completion of fifty years of the Geological Magazine, and was indeed one of the four famous geologists, then surviving, who had contributed to the 1864 volume of that journal, viz., the Rev. O. Fisher, M.A., F.G.S.; Sir Archibald Geikie, O.M., K.C.B., P.Pres.R.S., etc.; Professor W. Boyd Dawkins, M.A., D.Sc., F.R.S.; and Professor Hull, M.A., LL.D., F.R.S., etc., Professor Hull himself having during the fifty years made 119 communications to this Magazine. We had prepared a complete list of the titles of Hull's books and papers, amounting in all to over 250. As a selected series had already been published by Professor Hull at the end of his *Reminiscences of a Strenuous Life* in 1910, and the full list would have occupied more than ten pages, we could not devote so large a space in this number, and the intention had therefore reluctantly to be abandoned.—Editor Geol. Mag.

GEORGE CHARLES CRICK.

Born October 9, 1856. Died October 18, 1917.

Born at Bedford on October 9, 1856, the son of Dr. F. W. Crick of that town, George Charles Crick was educated at the Modern School there. Subsequently he passed through a course of studies at the Royal School of Mines, South Kensington, from 1875 to 1881. His career there was noteworthy, for he successively passed 1st Class in Physics (1875–6), 1st Class in Biology (1876–7), 2nd Class in Chemistry (1877–8), 1st Class in Geology (1878–9), 1st Class in Mechanics, 2nd Class in Mineralogy, 2nd Class in Palæontology (1879–80), and 1st Class in Mechanical Drawing (1880–1), thus winning the Associateship.

For some short time he acted as one of the curators to a notorious private collector, but on January 1, 1881, he entered on duty as Clerk and Assistant Secretary to "H.M. Commission to enquire into Accidents in Mines, etc.", of which Sir Warington W. Smyth was

Chairman, and he continued to act in that capacity till the termination of the Commission in 1886.

Meantime in November, 1881, he undertook work in a voluntary capacity in the Geological Department of the British Museum (Natural History), and was then employed as a temporary Assistant in 1882; on April 19, 1886, he was taken on the establishment as an Assistant of the Second Class.

At the Museum he was given charge of the Fossil Cephalopoda, then much in need of attention, and throwing his whole heart into the work has left it one of the best arranged and indexed collections in the institution.

This group was at that time in process of being catalogued by Mr. A. H. Foord, who writes as follows: "I had the happiness of knowing the late Mr. G. C. Crick for many years, as I was intimately associated with him in the Geological Department of the British Museum. Our work running on similar lines we wrote several papers jointly for this Magazine and for the *Annals and Magazine of Natural History*. Great patience and minute attention to details were conspicuous in all his work, and his researches were therefore highly valued by students of palæontology in the branch which he made his own, viz. the Belemnites and the Ammonites. He will be greatly missed by all his colleagues." Crick further assisted Foord largely with the first two volumes of the *Catalogue of Fossil Cephalopoda in the British Museum*, issued in 1888 and 1891, and was joint author with Foord of the third volume (Bactrites and Ammonoidea, *pars*), published in 1897: whilst he compiled the *List of Types and Figured Specimens of Fossil Cephalopoda in the British Museum* (*Natural History*), which saw the light in 1898.

Sixty-seven papers, including seven written in association with A. H. Foord, and one with R. Bullen Newton, stand to Crick's credit in various scientific publications. In the course of these, seventy-four new species are described and three new genera founded (*Amphoreopsis*, *Styracoteuthis*, and *Belemnocamax*). This is quite a moderate number for any student of fossil Cephalopoda, but his inclinations were ever toward the morphological side of his subject, and especially any feature of mechanical interest. This is very evident in his beautifully constructed model of the *Ascoceras* shell, and of the guard and phragmocone of the Belemnite, as well as in the question of the attachment of the animal to its shell in Nautiloids and Ammonoids. The first instalment of his memoir on this last question, that dealing with the Ammonoidea, was brought before the Linnean Society of London in 1898, and appeared in their Transactions. This important communication was very highly esteemed, and led, in conjunction with his other work, to the award by the Geological Society in 1900 of a moiety of the Barlow-Jameson Fund. The second part of the memoir, that treating of the Nautiloidea, was practically complete at the time of his death, and it is hoped that, with other of his literary remains, this may yet be published. Indeed, it would have appeared before had it not been for the meticulous care he bestowed on all his writings, which led him to withhold them from publication until

satisfied that the last possible item of information had been obtained, whilst a contributing cause of delay was to be found in the state of his health.

Never robust, he became on more than one occasion so seriously ill that his life was despaired of; still, he made marvellous recovery, and for some years had been so much better that he even participated for a time in Red Cross work. Whilst conscious himself of his precarious condition, he happily had no premonition of his sudden end, and the afternoon before was discussing with Dr. Kitson the geological age of some Ammonites from Nigeria, and making plans for future work. The following morning he passed quietly away at his Wimbledon home, and a few days later was interred at Luton.

Modest, quiet, and unassuming, ever ready to assist others, Crick endeared himself to all with whom he came in contact; even one who had not seen much of him writes "he always seemed a lovable little man". As such he will be sincerely mourned, not only by his widow, but by a very wide circle of friends.

Crick was elected a Fellow of the Geological Society in 1881; he joined the Geologists' Association in 1887; was one of the original members of the Malacological Society of London on its foundation in 1893; was elected a Fellow of the Zoological Society in 1896; and of the Royal Geographical Society in 1916. He was also a member of the Bedfordshire Natural History Society, of which his father was one of the founders, and frequently read papers before them.

B. B. Woodward.

List of the Scientific Writings of G. C. Crick.

1889. (In association with A. H. Foord.) "On the Muscular Impressions of *Cœlonautilus cariniformis*, J. de C. Sowerby, sp., compared with those of the Recent *Nautilus*": Geol. Mag., Dec. III, Vol. VI, pp. 494–8, 2 woodcuts.

1890. (In association with A. H. Foord.) "On the Muscular Impressions of some Species of Carboniferous and Jurassic Nautiloids compared with those of the Recent *Nautilus*": Ann. Mag. Nat. Hist., ser. VI, vol. v, pp. 220–4, 6 text-figs.

(In association with A. H. Foord.) "Descriptions of new and imperfectly defined species of Jurassic Nautili contained in the British Museum (Natural History)": ibid., pp. 265–91, 18 text-figs.

(In association with A. H. Foord.) "On some new and imperfectly defined species of Jurassic, Cretaceous, and Tertiary Nautili contained in the British Museum (Natural History)": ibid., pp. 388–409, 9 text-figs.

1893. (In association with A. H. Foord.) "On a New Species of *Discites* (*Discites Hibernicus*) from the Lower Carboniferous Limestone of Ireland": Geol. Mag., Dec. III, Vol. X, pp. 251–4, woodcut.

1894. (In association with A. H. Foord.) "On the Identity of *Ellipsolites compressus*, J. Sowerby, with *Ammonites Henslowi*, J. Sowerby": ibid., Dec. IV, Vol. I, pp. 11–17, pl.

(In association with A. H. Foord.) "On the *Temnocheilus coronatus*, M'Coy, from the Carboniferous Limestone of Stebden Hill, near Cracoe, Yorkshire": ibid., pp. 295–8, woodcut.

"On a Collection of Jurassic Cephalopoda from Western Australia—obtained by Harry Page Woodward, F.G.S., Government Geologist—with Descriptions of the Species": ibid., pp. 385–93 and 433–41, Pls. XII and XIII.

(Review.) "*Nanno*, a new Cephalopodan type," by J. M. Clarke: ibid., pp. 561–2.

1895. "On a New Species of *Prolecanites* [*P. similis*] from the Carboniferous Limestone of Haw Bank Tunnel, Skipton, Yorkshire": Trans. Manchester Geol. Soc., vol. xxiii, pp. 80–8, 4 pls.

1896. "Notes on some Fragments of Belemnites from Somaliland": GEOL. MAG., Dec. IV, Vol. III, pp. 296–8.

"On *Goniatites evolutus* (Phillips) and *Nautilus elongatus* (Phillips), etc.": ibid., pp. 413–19.

"On a Specimen of *Coccoteuthis hastiformis*, Rupp., sp., from the Lithographic Stone, etc.": ibid., pp. 439–43, Pl. XIV.

"On the Aperture of a Baculite from the Lower Chalk of Chardstock, Somerset": Proc. Malac. Soc., vol. ii, pp. 77–80, text-figs.

"On the Pro-ostracum of a Belemnite from the Upper Lias of Alderton, Gloucestershire": ibid., p. 117, pl. ix.

1897. "On an example of *Acanthoteuthis speciosa*, Münster, from the Lithographic Stone, Eichstädt, Bavaria": GEOL. MAG., Dec. IV, Vol. IV, pp. 1–4, Pl. I and woodcut.

"On the Fossil Cephalopoda from Somaliland, collected by Dr. Donaldson Smith": Appendix F in Dr. Donaldson Smith's *Through Unknown African Countries*, pp. 426–9.

1898. "On an example of *Acanthoteuthis Ferussacii*, Münst., from the Lithographic Stone of Solenhofen, Bavaria": Proc. Malac. Soc., vol. iii, pt. i, pp. 57–60, pl. i, etc.

"On the Muscular Attachment of the Animal to its Shell in some Fossil Cephalopoda (Ammonoidea)": Trans. Linn. Soc., ser. II, vol. vii, pt. iv, pp. 71–113, pls. xvii–xx.

"Descriptions of new and imperfectly known species of *Nautilus*, from the Inferior Oolite, preserved in the British Museum (Nat. Hist.)": Proc. Malac. Soc., vol. iii, pt. iii, pp. 117–39, 15 illustrations.

"On a deformed example of *Hoplites tuberculatus*, Sby., from the Gault of Folkestone": GEOL. MAG., Dec. IV, Vol. V, pp. 541–2, text-fig.

1899. "Note on *Ammonites euomphalus*, Sharpe": ibid., Vol. VI, pp. 251–6, text-figs.

"On some new or little-known *Goniatites* from the Carboniferous Limestone of Ireland": Ann. Mag. Nat. Hist., ser. VII, vol. iii, pp. 429–54, text-figs.

"Notes on the Fossils from the Chilian Andes, collected by Mr. Fitzgerald's Expedition": Appendix B in E. A. Fitzgerald's *The Highest Andes*, pp. 333–7.

"Note on *Ammonites calcar*, Zieten": GEOL. MAG., Dec. IV, Vol. VI, pp. 554–8, text-figs.

1900. "On the Horizon and Locality of *Nautilus truncatus*, Sowerby": ibid., Vol. VII, p. 154.

"Note on *Nautilus* (*Ephippioceras*) *clitellarium*, Sowerby": ibid., p. 560.

"Note on Zieten's type-specimens of *Ammonites polygonius* and *Amm. discoides*": ibid., p. 561.

1901. "A Chalk Ammonite, probably *A. Ramsayanus*, Sharpe": ibid., Vol. VIII, pp. 251–3.

"Note on a Dibranchiate Cephalopod from the London Clay of Sheppey": Proc. Malac. Soc., vol. iv, pp. 256–8.

1902. "On the type-specimen of *Belemnoteuthis montefiorei*, J. Buckman": ibid., vol. v, pp. 13–16, pl. i.

"Additional Note on *Ammonites calcar*, Zieten": GEOL. MAG., Dec. IV. Vol. IX, p. 47.

"Note on the genus *Tmægoceras*, Hyatt": ibid., pp. 127–8.

"Note on *Nautilus robustus*, Foord & Crick": ibid., pp. 342–6.

1903. "Note on Dr. J. E. Gray's type-specimens of Jurassic Ammonites from India": Proc. Malac. Soc., vol. v, pp. 285–9.

"On *Ammonites robustus* (R. Strachey, MS.), H. F. Blanford, from the Himalayas": ibid., pp. 290–5, text-fig.

"Notes on some specimens of straight-shelled Nautiloidea, collected by the Rev. Samuel Couling, M.A., Ching Chow fu, Kiachow, North China": GEOL. MAG., Dec. IV, Vol. X, pp. 481–5, Pl. XXII.

"Note on *Vestinautilus crassimarginatus*, A. H. Foord": ibid., pp. 552–5.

1904. "Note on *Pericyclus fasciculatus*, F. M'Coy, sp.": ibid., Dec. V, Vol. I, pp. 27–33.

"Notes on the Cephalopoda belonging to the Strachey Collection from the Himalaya": ibid., pp. 61–70, 115–24.

"Note on a remarkable Belemnoid from the Chalk of Flamborough Head": Proc. Geol. Assoc., vol. xviii, pp. 283–5, figs.

"Note on *Actinocamax*, Miller; its identity with *Atractilites*, Link.": GEOL. MAG., Dec. V, Vol. I, pp. 407–10.

"Note on two Cephalopods obtained by Lieut.-Col. Skinner, R.A.M.C., from the Valley of the Tochi River on the N.W. Frontier of India": ibid., pp. 490–3.

"Description of a Nautiloid, *Pleuronautilus pulcher*, n.sp., from the Carboniferous Rocks of England": Proc. Malac. Soc., vol. vi, pp. 15–20, pl. ii.

"On a new form of Carboniferous Nautiloid (*Amphoreopsis paucicamerata*) from the Isle of Man": ibid., pp. 134–7, pl. viii.

1905. "On a Dibranchiate Cephalopod, *Styracoteuthis orientalis*, n.gen. and n.sp., from the Eocene of Arabia": ibid., pp. 274–8.

"On a specimen of *Cyrtoceras* (*Meloceras*) *apicale* [Foord] from the Carboniferous Limestone, Kniveton, Derbyshire": GEOL. MAG., Dec. V, Vol. II, pp. 62–5.

"On some Fossil Cephalopoda from North Cornwall, collected by Mr. Howard Fox, F.G.S.": ibid., pp. 154–60.

1906. "Note on a rare form of *Actinocamax* (*A. grossouvrei*) [Janet] from the Chalk of Yorkshire": *Naturalist*, pp. 155–8, pl. xvi.

1907. "Cretaceous Fossils of Natal": Third Report Geol. Surv. Natal, pp. 163–250, pls. x–xv.

"The Cretaceous Rocks of Natal and Zululand and their Cephalopod Fauna": GEOL. MAG., Dec. V, Vol. IV, pp. 339–47.

"Note on two rare forms of *Actinocamax* from the English Upper Chalk": ibid., pp. 389–95.

"On the Arms of the Belemnite": Proc. Malac. Soc., vol. vii, pp. 269–79, pl. xxiii.

1908. (In association with R. Bullen Newton.) "On some Jurassic Mollusca from Arabia": Ann. Mag. Nat. Hist., ser. VIII, vol. ii, pp. 1–29, pls. i–iii.

1909. "Note on two Cephalopods collected by Dr. A. P. Young on the Tarntaler Köpfe, in Tyrol": GEOL. MAG., Dec. V, Vol. VI, pp. 443–6, Pl. XXVI.

1910. "On *Belemnocamax boweri*, n.g. et sp.": Proc. Geol. Assoc., vol. xxi, pp. 360–5, pl. xxviii.

"Note on two Cephalopods from the Chalk of Lincolnshire": GEOL. MAG., Dec. V, Vol. VII, pp. 345–8, Pl. XXVII.

"Note on the type-specimens of *Ammonites cordatus* and *Ammonites excavatus*, J. Sowerby": ibid., pp. 503–5.

"Snakestones": *Naturalist*, pp. 145–6.

1911. "Notes on Carboniferous Cephalopoda from the neighbourhood of Exeter": Quart. Journ. Geol. Soc., vol. lxvii, pp. 399–413.

1915. "Note on *Nautilus Mokattamensis*, A. H. Foord, from the Eocene of Egypt": Proc. Malac. Soc., vol. xi, pp. 286–90, pl. and text-figs.

"On a Dibranchiate Cephalopod (*Plesioteuthis*) from the Lithographic Stone (Lower Kimmeridgian of Eichstädt, Bavaria)": ibid., pp. 313–18, pl.

1916. "Note on a gigantic Cephalopod Mandible": GEOL. MAG., Dec. VI, Vol. III, pp. 260–4.
"Note on the Carboniferous Goniatite *Glyphioceras vesiculiferum*, de Koninck, sp.": Proc. Malac. Soc., vol. xii, pp. 47–52.
"On *Ammonitoceras tovilense* [n.sp.] from the Lower Greensand (Aptian) of Kent": ibid., pp. 118–20, pl. vi.
1917. "Note on the type-specimen of *Crioceratites bowerbankii*, J. de C. Sowerby": ibid., pp. 138–9, pl. vii.
"Recent Researches on the Belemnite Animal": Abstr. Proc. Geol. Soc., Sess. 1916–17, pp. 12–13.

MISCELLANEOUS.

THE ROYAL SOCIETY MEDALS: AWARDS FOR SCIENTIFIC RESEARCH.—Of the two Royal Medals to be awarded this year by the President and Council of the Royal Society, the King has approved of one being awarded to Dr. John Aitken, F.R.S., for researches in cloudy condensations, and the other to Dr. Arthur Smith Woodward, F.R.S., F.L.S., V.P.G.S., Keeper of the Department of Geology in the British Museum (Natural History), and one of the Editors of the GEOLOGICAL MAGAZINE, for his researches in Vertebrate Palæontology. We offer him our hearty congratulations on this well-merited honour. For his life and portrait see GEOL. MAG. 1915, pp. 1–5, Pl. I.

THE WOODWARDIAN PROFESSOR OF GEOLOGY IN THE UNIVERSITY OF CAMBRIDGE.—This Chair, founded by Dr. John Woodward in 1722, and rendered illustrious by Professor Adam Sedgwick, who held it from 1818 till 1872, when he was succeeded so happily by one of his former pupils, Professor T. McKenny Hughes (1873–1917), is now followed by another well-known Cambridge geologist, John Edward Marr, Sc.D., F.R.S., who for thirty years or more has fulfilled the important post of University Lecturer in Geology and College Lecturer in St. John's. This election by the Senate has been received with great satisfaction not only by University men but by geologists at large, amongst whom Professor Marr is well known and universally esteemed. A sketch of his life and work, with a portrait, as an "Eminent Living Geologist", appeared in this journal in July, 1916 (pp. 289–95, Pl. XI).

LENHAM BEDS AND MIOCENE ROCK FROM THE NORTH SEA.—Mr. R. B. Newton, who recently described these interesting deposits in the *Journal of Conchology*, xv, 1916–17 (GEOL. MAG., June, July, 1917), and Quart. Journ. Geol. Soc., lxxii, 1916, respectively, has now arranged a temporary exhibition series of the two faunas. Those interested can see these specimens in the Gallery of Fossil Mollusca at the British Museum (Natural History), on request, during the next few months.

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